Space Weather Technical Forecast

Issued on Sunday, 04 September 2022 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-class flares (R1-R2 Blackouts). G1/G2 Minor/Moderate Geomagnetic Storm expected day 1 and day 2 (4th & 5th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low with periods of C-class flares throughout, the largest being a C6 observed at 04/0300 UTC, originating from AR3089. There are four sunspot regions on the visible disc. The largest and most complex remains AR3089, approaching the southwestern limb. This region continues to grow, with proliferation of spots on its trailing portion, these merging into a large homogeneous penumbra. The connection of the positive delta region within the largely negative trailing portion has led to a classification of Eki/Beta-Gamma-Delta. AR3093 has developed rudimentary penumbra around both the leading and trailing portion of the spot, though it remains rather small. AR3092 and AR3094 also remain relatively small and simple, with no or limited growth.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was indicative of a transition from one HSS into another stronger HSS, most likely from CH19/+ into CH20/+. The solar wind speed fell from 550 km/s to 480 km/s before then increasing to 670 km/s during the 4th. Density was around average or just above throughout, with a max of 16ppcc at 03/2358 UTC. Total interplanetary magnetic field strength (IMF), Bt, was initially weak but became moderate from 03/2345 UTC reaching a peak of 13nT at 04/0145 UTC. The north-south component, Bz, was mostly negative, with sustained periods of moderate to weak negative Bz during the 4th, with fluctuations between +8/-12 Bz. The Phi angle was almost entirely positive (toward the sun). Geomagnetic activity was Unsettled (Kp3) initially, before intervals of successive G1/Minor, G2/Moderate and G3/Strong storms (Kp5, 6 and 7 respectively) were observed using BGS data during 4th September.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV), as measured at GEOS-16 was at background levels. The high energy electron flux (greater than 2 MeV) fluctuated between background and moderate levels. The 24-hour integrated electron fluence remained well below the Active threshold (1e8 integrated pfu) but displayed a slight rising trend, with 6.95e6 integrated pfu observed at 04/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain largely Low, with an ongoing chance of Moderate flares, mostly from AR3089. This spot will likely exert influence on the flare risk due to it's location until the end of day 4 (7th). A new region may rotate onto the northeast limb on day 2 (5th), potentially increasing the probabilities of significant flares.

Solar Wind / Geomagnetic Activity: The CME that left the sun on 2nd Sept may give Earth a glance on day 2 (5th). No other Earth-directed CMEs expected. Solar winds are initially expected to be strong on day 1 (4th) due to the HSS from CH20/+. Solar wind speeds will gradually ease to elevated by day 2 (5th) before a brief rejuvenation due to the CME. Solar winds should then fall back to slightly elevated by day 3 (6th) or day 4 (7th). Further periods of G1/Minor to

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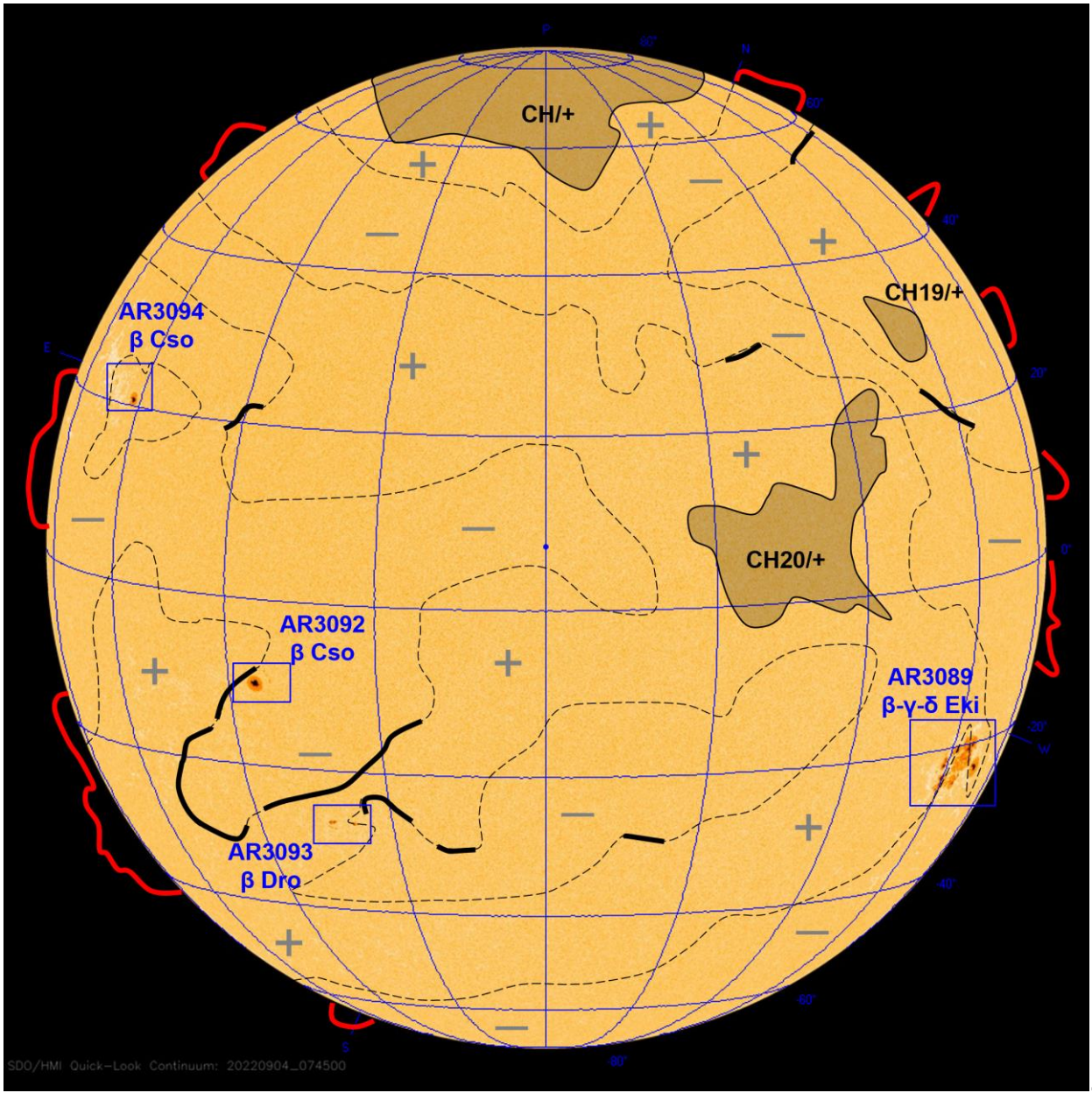
G2/Moderate Geomagnetic Storms are expected on day 1 (4th) and into day 2 (5th), with a slight chance of further G3/Strong (Kp7) Storms. The baseline Geomagnetic activity should begin to reduce to Quiet to Unsettled into day 3 (6th), or perhaps day 4 (7th).

Energetic Particles / Solar Radiation: High energy protons (greater than 10 MeV) are expected to remain below S1/Minor radiation storm levels. The high energy (greater than 2 MeV) electron flux is expected to rise erratically and become high over the following days. The corresponding 24 hour fluence is expected to display a sharp rising trend from day 1, with a chance of exceeding the Active threshold on day 2 (5th) then expected from day 3 (6th) onward.

Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A marked filament eruption was observed leaving the sun on 2nd September. The CME that followed may give a glancing blow at Earth on day 2 (5th), with a possible arrival time around midday UTC. ENLIL suggests only a slight perturbation in the already elevated wind speeds on 5th Sept, this is considered to be good guidance with minimal overall impact at Earth above the already heightened baseline.

Solar winds are currently strong due to the HSS originating from CH20/+. Solar winds are expected to remain strong or elevated through the first half of the period before slightly declining as we exit the influence of CH20/+ by day 3 (6th). There remains uncertainty around a potentially complex region shortly following CH20/+ in the northern hemisphere. On the last rotation there was a large coronal hole following CH20/+ but currently there seems to be little evidence of this, therefore both ENLIL and SWPM may be artificially holding on to the higher solar wind speeds for an extended period.

Further periods of G1/Minor to G2/Moderate Geomagnetic Storms are expected on day 1 (4th) and into day 2 (5th), with a slight chance of further G3/Strong (Kp7) Storms. The baseline Geomagnetic activity should begin to reduce to Quiet to Unsettled into day 3 (6th), or perhaps day 4 (7th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	90	70	20	10
Strong	G3	No	15	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/0742	Nil	Filament Eruption	SE	750 km/s	05/1200 UTC	Glancing blow probable

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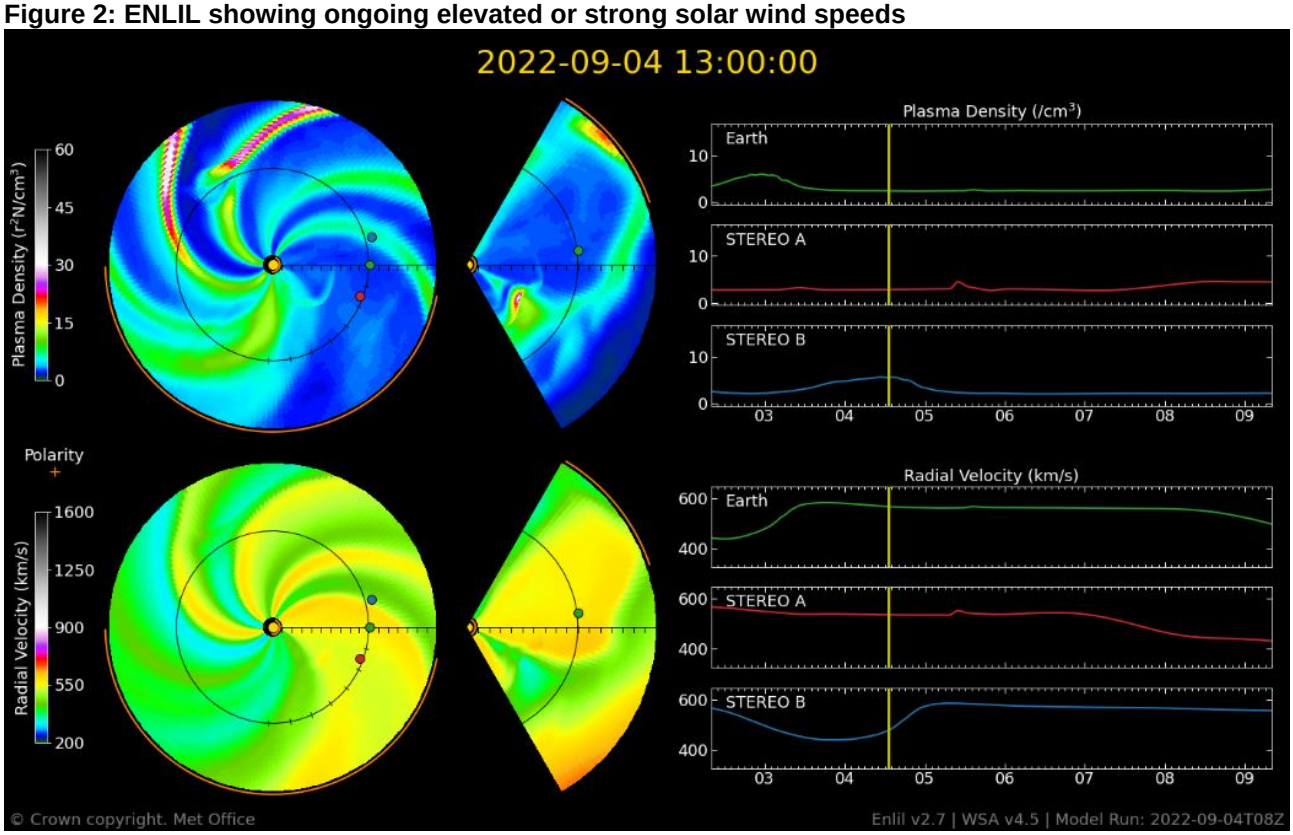
Figure 2: ENLIL showing ongoing elevated or strong solar wind speeds



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Radio Blackouts - X-Ray Flares:

There are four sunspot regions on the visible disc. The largest and most complex remains AR3089, approaching the southwestern limb. This region is growing rapidly, though no M-class flares have been observed from this sunspot throughout it's life so far. The trailing region has a large homogeneous penumbra, now around 7 degrees between it's most northern and most southern extents. This spot has a delta region, with a positive portion connected to the largely negative trailing portion. It's classification as a Eki/Beta-Gamma-Delta suggests more activity should have been experienced than it has given so far. It's continued growth is an indicator of future increased activity and the percentage risk of M and X class flares reflect this. The other 3 sunspots remain mostly small and simple.

A large filament is visible in the southeast quadrant and will need to be monitored for any lift-off, particularly when it approaches the central meridian.

Solar activity is expected to remain largely Low, with an ongoing chance Moderate flares at times, mostly from AR3089. However the farside solar map from Raben Systems, Inc indicates the presence of an active region approaching the northwest limb. It is currently not visible on the EUVI/AIA 195 imagery but may rotate onto the northeast limb at the end of day 2 (05th), potentially increasing the probabilities of significant flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	45	45	45
Very Active	R3 to R5 X Class	No	5	5	5	5

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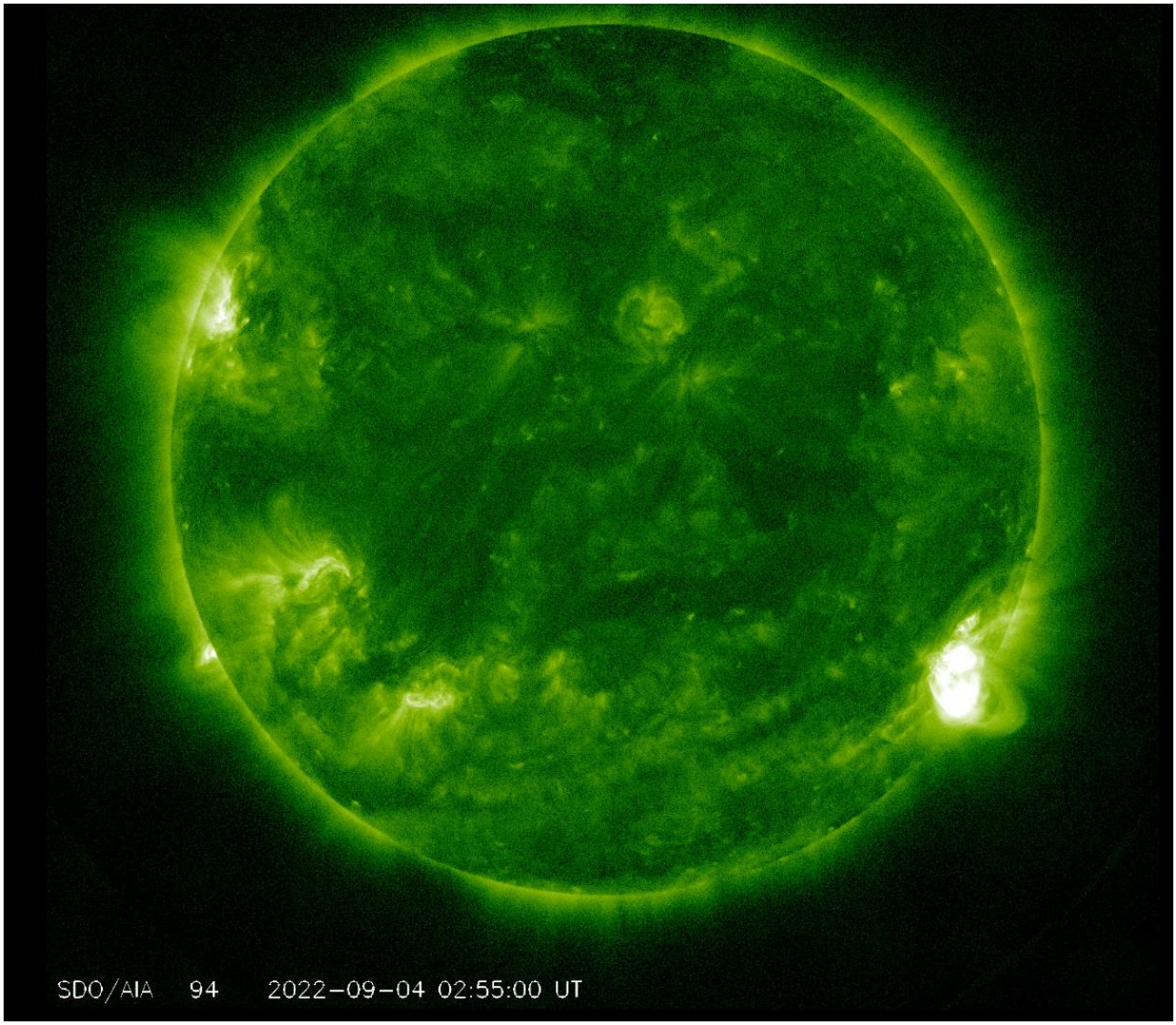
Figure 3: C6 flare from AR3089 on SDO94 imagery from 04/0300 UTC



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) remains at background values. Despite and apparent stability, AR3089 (Eki/Beta-Gamma-Delta) continues to present a slight chance of a proton event at Earth, should there be any significant flaring. This risk will continue as the region rotates further across the southwestern quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	3	3	3	3
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux has become moderate, due to the recent enhancement from the fast speed streams originating from CH19/+ and CH20/+, recharging the Van Allen belts in electron populations. In the coming 24 hours, the electron flux may reach high levels due to continued charging, however the current geomagnetic activity is temporarily aiding to suppress the electron counts, though there remains a great deal of uncertainty. Flux levels are then expected to rise erratically during day 1 (4th) and day 2 (5th), before comfortably remaining above high levels during day 3 (6th) and day 4 (7th).

The corresponding 24-hour fluence is expected to continue displaying the rising trend from day 1 (4th), with a chance of exceeding the Active threshold from day 2 (5th) then expected from day 3 (6th) onward. This is supported the latest Met Office REFM output, although the model is currently slightly under-estimating fluence levels.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	40	70	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	5

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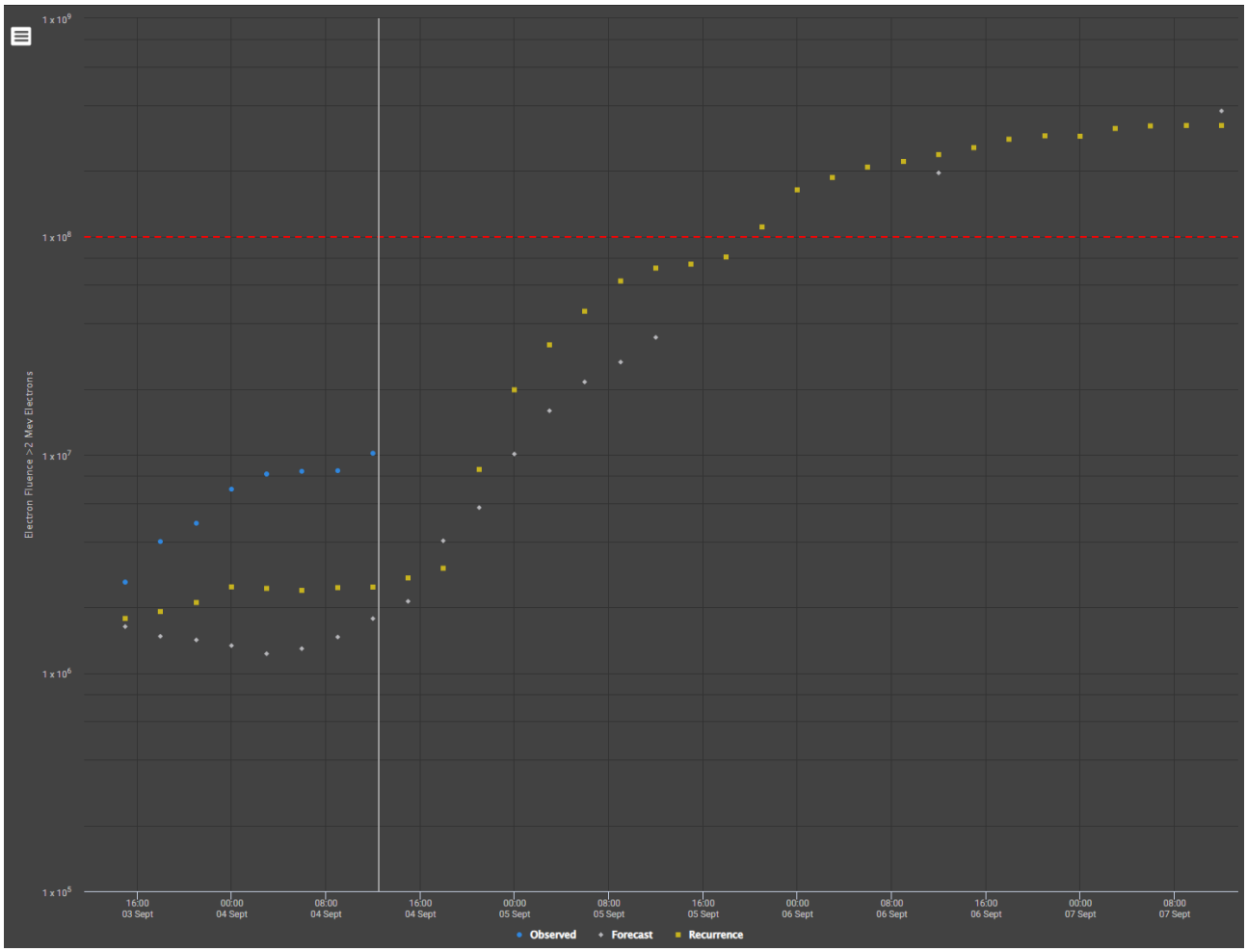
Figure 5: REFM showing fluence observations, forecast and persistence



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